

Climate variability and Agricultural Policy in Morocco

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Abstract

Two distinctive features seem to be driving the agricultural sector in Morocco. The first is what appears to be an increased frequency of drought, with six of the last ten years characterized as drought years. The second is the continued protective policy that the government maintains on different agricultural commodities, primarily cereals. We employ an enhanced general equilibrium model that examines the long run impacts of trade liberalization policy under alternative climate outcomes. Our results indicate that returns to factors of production are bid up under favorable climate and decline dramatically in the bad state of nature. This behavior is transmitted to households' welfare. With complete wheat trade liberalization, we find that landowners are the primary losers irrespective of the state of nature realized. The urban sector gains. There is also evidence that livestock capital help mitigate the negative impacts of liberalization in the event of drought, especially for small farmers.

Introduction

As it enters the new century, two features of the Moroccan economy stand out. The first is its agricultural policy. Despite the important structural reforms that the country has implemented from the mid 1980's, and its accession to the WTO, protection on strategic agricultural commodities, such as wheat and sugar, remains high. These commodities are protected at the border by high and variable trade barriers with the goal of stimulating the rural sector and reducing transmission of world price variability in domestic markets. They are then subsidized in the domestic markets to make them affordable to consumers.

The second feature of the Moroccan agricultural economy is climatic variability, in particular drought. Although, drought is not a recent problem, its frequency has been increasing in the last twenty years. Six of the last ten years could be characterized as drought years with 1995 being the most severe at 225 mm average rainfall level. Despite the increase in total irrigation area (Swearingen, 1987), it still represents only about 16% of total available land (RGA¹). The remaining acreage is rainfed making it dependent on a volatile rainfall distribution.

We employ an enhanced general equilibrium model that examines the long run impacts of wheat trade liberalization policy under alternative climate outcomes. This paper is divided into four main sections. Section 1 provides the motivation for this

¹ Recensement General de L'Agriculture, Morocco 1996

analysis. It provides a background of the economic situation in Morocco, presents the climatic variability problem, and relates it to the production structure in the economy. It also describes the existing policy of protection for the cereals sector. Section 2 presents the general equilibrium model, and the data utilized in this analysis. Section 3 discusses the simulations undertaken and the results and implications derived. Finally, section 4 concludes.

The Economy

Morocco's economy has gone through a series of changes since independence. Average annual growth in GDP between 1980-1990 was equal to 4.2 percent. In the 1990's growth dropped down to 2.3 percent. Variability in GDP has been substantial in recent years. In 1995, following a severe drought, GDP growth was negative at - 6.5 percent. It jumped to a positive 6.8 percent in 1998, and dropped again to - 0.7 percent in 1999, (World Bank country data).

The three major sectors of the economy are agriculture with 15 percent of GDP (1999), industry with 33 percent, and services with 52 percent. The sectors employ 50, 15, and 35 percent of total labor force respectively. Despite its relatively modest share, the agricultural sector has been a major determinant of overall economic performance. The sector contributes about 26 percent of total exports. The average growth of agricultural value added from 1990 to 1999 was 0.0 percent, down from 6.7 percent in the previous decade. Plagued by periodic droughts and significant rainfall variability, the very large variability in agricultural value added growth has translated into volatile GDP growth. Figure 1 shows the annual variations in agricultural, non-agricultural, and total GDP in Morocco.

The figure suggests that agriculture has been the primary source of output variability. Non-Agricultural GDP has been relatively stable over the years. The variability in agricultural GDP and total GDP has increased significantly in the last ten years, as the graph illustrates. This primarily has been the result of increased rainfall variability.

Climate Variability and Cereal Production

The climate in Morocco is essentially Mediterranean. Summers are typically dry and winters are moderate, (Mdafri, 1996). Most rainfall occurs between the months of October and March. Monthly rainfall variability is highly significant. The coefficient of variation between the months of November and April exceeds 50 percent. The coefficient of variation for annual variability is equal to 20 percent (Skees et al, 2000). Drought is believed to be a decadal phenomenon. However, data from the last two decades seem to suggest an increase in its frequency.

In an attempt to predict rainfall levels and potential drought, a group of Meteorologists at the University of Oklahoma have identified an inverse relationship between rainfall and the North Atlantic Oscillation (NAO). The hypothesis suggests that the higher the NAO index, the lower the predicted rainfall. After El Nino, NAO is the

most dominant large-scale pattern of natural climate variability with important impacts on the weather and climate in the North Atlantic region and surrounding continents. There is some optimism that with current day climate models, probabilistic forecasts of the NAO a season ahead may be possible. If the state of the NAO could be forecasted in advance, season climate forecast could be made.

Over the course of last decade, climatic outcomes in Morocco could be characterized by a bimodal distribution. Mainly two states of nature could be delineated, good and bad. In the data, the correlation between *annual* rainfall and cereal production levels is rather weak. A combination of the level and the timing of rainfall makes the difference between a good and a bad year. Below average rainfall could correspond with an excellent crop year if the timing is good. The converse is also true. Due to the complexity of the relationship between climate and production, we use historical production levels as a proxy for rainfall (quantity and timing).

If we observe cereal production levels in the last decade (Figure 3 below), we notice that the years 1991, 1994, and 1996 could be characterized as good years, and 1992, 1993, and 1995 as bad years. Production levels in the good years are higher than one standard deviation above the long-term average cereal production level. Similarly, production levels in bad years are less than one standard deviation below the long-term average value. The remaining years, where production levels fall between one standard deviation away from the mean are considered normal.

The principal commodities that will be focused upon in this analysis are cereal crops. The major cereal crops are soft wheat, hard wheat, barley, maize, and other cereal crops. The cropping pattern in Morocco is dominated by cereals, with two thirds of the total cropping activity covered with cereal crops. Mostly a rainfed activity, cereal production has been negatively impacted by the observed high rainfall variability.

Table 1 includes the coefficients of variation (CV) for cereals production and yields. It separates the numbers between two distinctive time periods. The first ranges from 1971-1983, and the second covers the years 1987-1999. It is over the latter period that variability is more accentuated. The numbers demonstrate the significant level of variability in cereals yields and production, especially in the recent period. With the predominant share of the cereal activity in agricultural production, this variability is likely to be transmitted into overall agricultural production levels. Figure 3 also illustrates the relationship between cereal and agricultural production indices.

Previously, we showed how total GDP has been moving almost proportionally with agricultural GDP (Fig 1). Figure 3 illustrates the dependence of agricultural production on cereal production. Consequently, cereal production plays a decisive role in shaping output fluctuations in the economy.

Protection policy

The evolution of agricultural policy reform in Morocco is marked by three important events. Two structural adjustment loans were signed in 1985 and 1987. Among

the conditions of the loans were restructuring agricultural investment, reorient price and incentive programs to optimize resource allocation, eliminate price distortions in the cereals, sugar, oilseeds and inputs market, and do away with ONICL², the cereals market / trade monopoly state agency. The third important event was the signing of the Uruguay round agreements in Marrakech, Morocco in 1994. Morocco was committed to reduce tariffs on its agricultural commodities and adopt an *ad valorem* tariff system.

Despite the major reforms that were undertaken, such as liberalizing the inputs market and the oilseeds market recently, substantial protection persists on the cereal commodities, primarily in the wheat sector. Wheat is protected at the border through tariffs to protect producer's income and domestically through flour subsidies to assure a fair price for consumers. Wheat constitutes a major staple commodity for Moroccan households and a major source of income for Moroccan farmers, rendering it a strategic commodity with significant policy implications.

Wheat, however, is often thought to be less resistant to adverse climatic events than other cereal crops such as barley. It is worthwhile to mention that although the latter statement seems to be agreed upon by farmers and agronomists alike, an extensive literature search yielded no empirical support to this hypothesis. Nevertheless, the protection bias for wheat has caused a drastic increase in wheat acreage and a significant increase in overall acreage, pushing both wheat and other cereal crops to low quality lands, thus aggravating variability. Figures 4 and 5 present the evolution of soft wheat harvested acres, and the reduction in barley's acreage as a result of supported wheat prices. A special interest, is given to barley, a crop thought to be relatively robust under adverse growing conditions and essential for livestock feeding. This decline in barley's harvested acreage and the high variability in its production have contributed to a switch for Morocco from a barley exporter to a barley importer as depicted in figure 6. Also note the increased volatility in barley's imports in the last decade, corresponding to the increased frequency of drought.

A CGE model for Morocco

We have highlighted the dramatic climate variability that characterizes Moroccan agriculture. We have also underlined the importance of the wheat activity in particular and the cereals sector in general, in shaping the output variability in the country, and the vulnerability of the sector because of the observed climatic variability. Acknowledging that both of the issues in focus, climate variability and wheat trade liberalization, have economy-wide, we use a general equilibrium approach. The model is used to analyze both the short run impacts of alternative climate outcomes on different economic players. In addition, we examine the impact of removing border protection on wheat in different states of nature and derive policy implications.

The model developed for Morocco is a variant of CGE models in the tradition of Dervis, De Melo, and Robinson (1982). The model is based on an enhanced social accounting matrix for Morocco based on the year 1997. A complete description of the

² ONICL: Office National Interprofessionnel des cereals et Legumineuses.

basic model is provided in Logren (2001). Complete description of the enhanced model and the social accounting matrix is provided in Karaky (2002). Three unique features of the model should be highlighted.

First, CGE models are conventionally represented as $F(X, B) = 0$, where X represents the endogenous variables and B represents the exogenous parameters. We envisage n separate models based on n states of nature. In particular, we consider two different models corresponding to a drought and a good weather scenario. We also maintain the base, to examine simulations results in a normal year setting, where no weather shocks are considered. We represent our model by $F(X_n, B_n) = 0$, with $n = 3$. Further, we link the three models with a cross model restriction. This restriction constrains the factor allocation in the different states of nature to be equal to the base. This basically reflects short-term rigidities, whereby agents have to live with the resource allocation decision they make in the base, irrespective of the state of nature realized.

The second feature of the model is the differentiation between different climatic zones, especially in the rainfed areas. Nationwide provincial production data was utilized, in order to break the aggregate non-irrigated cereal production into production within three separate regions namely, favorable, intermediate, and dry based on rainfall levels. It was noted that most of the favorable zone is situated in the northern part of the country. The intermediate zone includes mainly Casablanca and Settat, while the dry zone is mostly represented by the Southern and Saharian region. Rainfed land is also differentiated into three land factors depending on the climatic zone. Because of our interest in cereal activities, we separate production levels for soft wheat, hard wheat, barley and maize, into the different climatic zones. We end up with sixteen production activities including those in the irrigated zone. Table 2 presents the production share for the different cereal activities in the different zones.

The third feature of the model is the inclusion of a risk premium parameter for every risky activity. Risk premia are calculated following the method used in Burfisher et al. (2000). We use historic real returns of every cereal activity in every zone, including the irrigated zone, to generate percentage values that reflect the level of variability in those returns and the covariate risk that exists between different activities in different zones. These parameters are included in the model following the method developed by Arndt et al (2000). For the purpose of clarity, we replicate few of the model's equations that include the risk parameters.

$$W_{s,f} \cdot WFDIST_{s,f,a} = (1 - Risk_A) \cdot PVA_{s,a} \cdot (1 - tva_a) \cdot QVA_{s,a} \cdot \left(\sum_f \delta_{s,f,a}^{va} \cdot QF_{s,f,a}^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{s,f,a}^{va} \cdot QF_{s,f,a}^{-\rho_a^{va}-1} \quad (1)$$

$$YF_{s,f,a} = \sum_a W_{F,s,f} \frac{WFDIST_{s,f,a}}{1 - Risk_A} \cdot QF_{s,f,a} \quad (2)$$

Primarily, the risk parameters are introduced in the first order condition of the value added production function (equation 1), where they drive a wedge between the value marginal product of factor f in activity a and its corresponding marginal cost. The riskier the activity is, the higher the wedge. They are also introduced in the factor income equation (equation 2), as premium to factor payment when employed in a risky activity. Riskless activities have a risk premium value of zero. The risk parameters do not vary with the states of nature realized as they represent more an inherent characteristic of the corresponding activity. They vary however, with the policy in place. Different policies have different effects on prices and consequently on variance covariance of returns, which are used to calculate the risk premia. Table 3 present the base level risk premia for the four major cereal activities.

Remaining aspects of the model are relatively standard. There are ten factors of production: rural labor, urban labor, urban capital, irrigated land (includes water), rainfed favorable land, rainfed intermediate land, rainfed dry land, capital crops (include machinery), capital livestock (include the animals, and the pastures), and other rural capital, relevant to forestry and fisheries. Factors combine in a CES fashion to produce value added. The latter combines in a Leontief fashion with aggregate intermediate to produce activity output. Activities from different climatic zones combines in a CES fashion to produce the final commodity.

The model includes six households, four rural and two urban. Rural Landless households rely primarily on rural wages with some urban work. Wages. Farm households are divided into small, medium, and large, based on size of farm exploitation. They rely on a variety of factors primarily different types of land, and livestock capital. Urban poor households earn their income exclusively from urban wages. The source of income for urban non-poor household is urban capital, followed by urban labor.

Other aspects of the model include a differentiation between imported goods and domestic goods with high elasticities for grains and other consumption commodities and low elasticities for production commodities. Similarly, on the export level, the model assumes imperfect transformability between exports and domestic sales, expressed by a constant elasticity of transformation (CET). The small country assumption is imposed. Morocco cannot influence world prices neither through its imports, nor through its exports. Other institutions in the model include rest of the world, which receives its income from export revenues and transfers from other institutions. It spends it on imports, and transfers to other institutions. Finally, the consumer price index is chosen to be the numeraire.

The model assumes the following closure specifications. Saving rates are fixed, and investment adjusts to the available savings pool. The absorption share for investment and government expenditure is flexible. For the government balance, it is assumed that tax rates are fixed, and that real government consumption is fixed. Government savings adjusts. As for the external balance, we replicate a structural characteristic of the Moroccan economy, by fixing the exchange rate and allowing the current account

(foreign savings) to adjust in the short run closure. In the long run, we fix foreign savings and let the exchange rate adjust.

Simulations

Two experiments are considered. The first simulates the short run impacts of two weather outcomes: good (s1) and bad (s2). Resources are fixed to their base level, as no recourse is possible. Typically the growing season in Morocco extends from mid October until May. Farmers could wait for the rain until the month of March, thus making it difficult to readjust the production plan in the case of low rainfall. Climate shocks are estimated for soft wheat, hard wheat, barley and Maize in all the climatic zones, using regression analysis. Shocks are introduced in the model as Hicks neutral technological shocks, which increase cereal yields in S1 and decrease them in S2. Table 4 presents the value of the shocks for all cereal activities in both states of nature.

The general belief, that barley is more tolerant than wheat in the event of drought, seems to hold only in the rainfed favorable zone. Across all other zones, yield discounts are pretty much similar. The most noticed swings in output changes, between the different weather scenarios, are observed in the intermediate rainfed zone. This is somehow expected as this region experienced the highest level of variability in crop returns, as was illustrated by the risk premia levels in table 3 above.

The next simulation examines the impact of trade liberalization in the wheat market, in the different weather scenarios. Border protection for wheat has resisted numerous calls for liberalization for many reasons, mainly protect against world market price variability and protect producer's income. Erratic climatic behavior, over the years, has added to the uncertain consequences of liberalization.

Because of the long run nature of this experiment we allow for flexibility in resource allocation and maintain the restriction of resource usage across states of nature. Furthermore, we fix foreign savings and allow the exchange rate to adjust. Exchange rate level in the two weather scenarios is fixed to the level in S0, which is variable, and foreign savings adjust. Other assumptions related to the government budget balance and saving investment balance remain unchanged.

Results

Initial results of experiment 1 indicate very wide swings in commodity prices across the different states of nature, particularly for barley. This is expected in the very short run, where crop production has little scope for adjustment. We compared this variability to the historic data and found that barley prices were at least two to three times more variable than the other cereal commodities. This creates substantial incentive for stockholdings. We capture stockholding by incorporating an upper and a lower bound on the price of barley across states of nature. Once the barley price hits the lower (upper) limit, barley stocks accumulate (decumulate). By normalizing the historic series of barley prices to the base year, we find that the lower limit is specified at approximately 65 percent of the base price in a good year, and nearly 140 percent in a bad year.

As expected, the results of experiment 1 suggest that output levels for all cereal commodities rise in s1 and decline in s2. While activity output levels in the different climatic zones reflect the magnitude of the climatic shocks, the aggregate commodity output across all zones show the following results: the increase in barley's output is the most recorded in s1, among the different four cereal commodities. Maize showed the largest output decline in s2. Table 5 present the percent output change for selected commodities in the model

Price effects were inversely related to the output effect. Largest swings in price changes across the different states of nature were observed for all cereal commodities. Limits on barley prices are binding. Price changes for different commodities are presented in table 6.

The results also suggest that real GDP at factor cost increased in the good weather scenario by 2.14 %, an amount roughly equal to the average value of the shock weighed by the share of the different cereal activities in total value added. It similarly decline by 1.6 % in the bad weather scenario.

As noted earlier, factors of production are fixed to the base across both states of nature. Results indicate that all factors employed in rural activities gain in s1, with the exception of irrigated land. The latter, which implicitly includes water as factor, experience more competition from the rainfed lands, due to less demand for water. Land returns in the rainfed dry regions are relatively higher than returns in the intermediate zones and the favorable zone. Rural labor gained as well as more of it is needed in agricultural activities with higher yields. Significant increases are recorded for livestock capital. Livestock, on the other hand, has always been considered as an asset for farmers to hedge against future bad climatic events. The demand for pastures and fallow, which are considered elements of livestock capital, has also increased driving up the returns to livestock capital.

In the event of bad weather scenario, factors of production experience losses in their returns, irrigated land excepted. The latter becomes a highly scarce resource in the time of drought prompting its returns to go up. Similarly returns to urban capital increase, as production activity would tend to shift towards urban commodities. Among the different types of rainfed lands, the one in the intermediate zone is hit the most. This is somehow expected as most of this zone is planted with maize crop, which was hit the hardest in the case of drought. Rural labor and livestock capital suffered significant losses as well.

Returns to factors of production determine the returns to households' income. The latter coupled with price and consumption changes determine the overall welfare changes. We use the equivalent variation measure to determine welfare changes for different households. Results are depicted in table 7 below. Numbers indicate that all households are better off in s1, and are all worse off in s2, albeit with different magnitudes. Landless households and urban poor experience the largest gains, followed by small farmers, urban non-poor and medium and large farmers. Similarly, welfare

losses in S2 were more pronounced for rural and urban poor. The impacts of different weather outcomes on poor households are particularly strong due to the net buying status of these households of food commodities. Medium and large farmers, who are net sellers of food products, have relatively fewer gains and losses.

The macroeconomic impacts of simulation 1 include as well significant swings in the trade deficit between the two states of nature. Cereal imports in general, and barley imports in particular, decrease (increase) dramatically in s1 (s2) reflecting the observed volatile import pattern during the last decade. With a fixed exchange rate, foreign savings decline in s1 and increase in s2 to maintain the current account balance. With less imports in s1, and fixed direct tax rates, government revenue from tariffs decline. Government consumption is held fixed, thus government savings adjust downwards. The opposite is observed in the bad weather scenario. On the spending side of the saving investment balance, investment declines in the good state of nature, as foreign savings, and government savings decline with private savings held fixed. By the same reasoning, investment increases in the bad weather scenario to maintain the saving investment balance.

Results of experiment 2 indicate that wheat liberalization causes declines in the price of wheat in all climate scenarios. On the other hand, prices of urban commodities such as industries and services increase. Change in prices cause resource reallocations, assumed flexible under this experiment. Land in the favorable rainfed zone, is redirected towards maize and other agricultural activities. In the intermediate zone, the shift is towards both barley and maize, and in the dry zone, most of land is reallocated primarily to barley. Similarly rural labor moves towards maize, barely and public administration activities.

Factor income changes are presented in table 8. Columns entitled “Tariff lib” correspond to a percentage change to factor returns from the base column that precedes it. In the table, three base cases are considered, one corresponding to the base year, and the others related to s1 (good year) and s2 (bad year) respectively. Percentage changes calculated between numbers in columns 3 and columns 1 correspond to the factor returns changes under the good state of nature in experiment 1. Similarly, percentage changes calculated between numbers in columns 5 and columns 1 correspond to the factor returns changes under the bad state of nature in experiment 1. We choose to present the results in this way in order to emphasize factor returns changes under the different weather scenarios.

In the normal year scenario, results show substantial decline in returns to land across all climatic zones, including land under irrigated production. The highest decline is recorded in the rainfed intermediate zone. Returns to capital crops decline sharply as well. Urban factors witness income growth, so does livestock capital and rural labor. Under the good weather scenario, land returns continue to suffer the most compared to the high returns in experiment 1. As a matter of fact all other factors experience a decline in their returns compared to their levels in the same state of nature in experiment 1, with the exception of urban capital. Land in the intermediate zone continues to be strongly

affected. In the case of the bad weather scenario, changes in factor returns are less accentuated. This is because of the already low base that we are starting from. Results suggest that factors returns to irrigated land experience the largest decline. This is expected as irrigated land was the only factor that experienced positive return in the previous short run experiment. Returns to livestock capital show significant positive gains, underlining the importance of livestock in mitigating the impacts of drought, in the case of a negative price shock.

Although the shares of different types of land in households' income are relatively modest, the large declines in their returns exceeded any positive changes in other factors, thus affecting households' welfare. In the absence of any weather consideration, S0, welfare results indicate that landless rural households, and urban households (both rich and poor) are better off, and all farm households are worse off. Medium and large farmers have more significant losses than small farmers. If trade liberalization was implemented following a good year all households are worse off compared to the good weather base. For example the percentage change in equivalent variation for landless households, from the base, following a good weather shock, was a positive increase of 23.7 percent. This level declines to 16.9 percent upon further liberalization of wheat resulting in a net loss of 6.8 percent due to the policy change. Sharpest welfare declines were still recorded for farm households. On the other hand if trade liberalization follows a bad weather shock, welfare changes resemble the case of no weather change. In other words, landless households, and urban households (poor and rich) are better off, while farm households are worse off. The rate of decline in welfare for farm household is however, less sharp as some of the welfare loss is mitigated by the increased return to livestock capital, as shown previously in table 8 above. Small farmers continue to largely depend on livestock as a source of income, especially in the bad weather scenario. It is noticed that landowners experience welfare losses following a tariff cut on wheat, irrespective of the states of nature realized. Albeit they have positive welfare changes in the good weather scenario, these changes become less positive upon further wheat liberalization. Changes in equivalent variation are depicted in table 9. Columns entitled Exp 1 were replicated from table 7 above.

As a result of liberalization, rapid wheat import expansion raises the trade deficit. As a result the real exchange rate depreciates at 2.7 percent to restore the current account balance.

Conclusion

This paper examined the impact of trade liberalization in the wheat sector of Morocco, across a range of weather realizations. To our knowledge, this is the first effort that differentiates among different climatic zones in the country, and account for weather considerations parallel to policy analysis. Numerous analyses tackled economic policy reforms in Morocco, and they all mentioned the problem of drought, but none modeled it explicitly.

We modified the CGE model by incorporating a cross model restrictions, and running a series of models simultaneously. We also account for risk by including risk premia derived from historical variability in activities' returns.

Our results indicate that in the short run, a good weather scenario is welfare enhancing, whereas a bad state of nature reduces welfare. Trade liberalization in the wheat commodity appears to reduce the welfare of farm households in all states of nature, by dramatically decreasing the returns to land across all climatic zones in Morocco. It enhances, however, the welfare of landless households and urban households suggesting that if coupled with complementary policies to compensate farm households, it could very well be a win-win policy. Livestock capital seems to play an important role in mitigating the negative effect of trade liberalization in the case of drought, thus alleviating some of the welfare loss experienced by small farmers.

Possible extensions to this work include a formulation of an expected utility problem in the different climatic zone. This problem could result in a portfolio type of resource allocation in the different activities varying based on risk parameters and policy shocks. One possibility could be to render the risk parameter endogenous, instead of regenerating them exogenously under the policy shock. Calibration could prove to be a challenge in this case.

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Figure 1. Annual variations in agricultural, non-agricultural and total GDP in Morocco

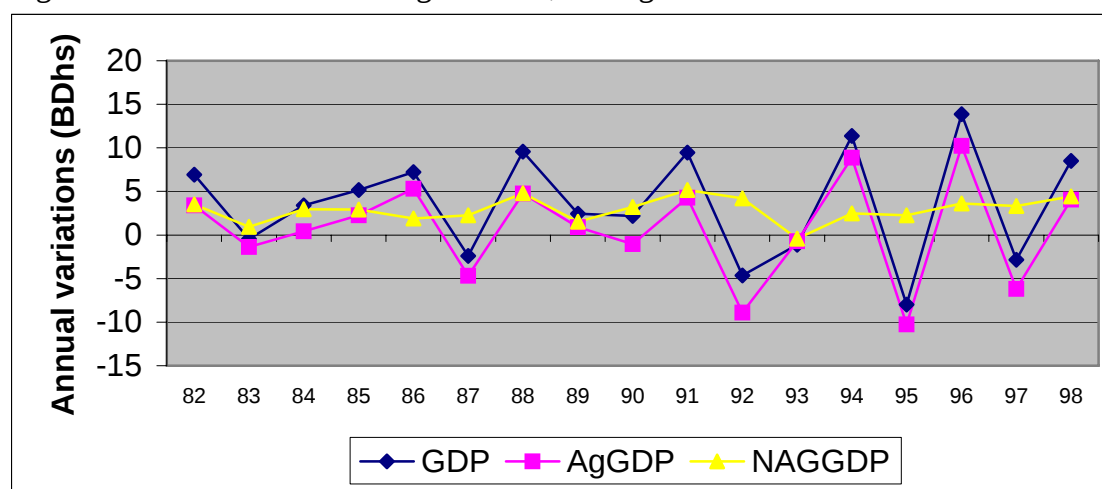
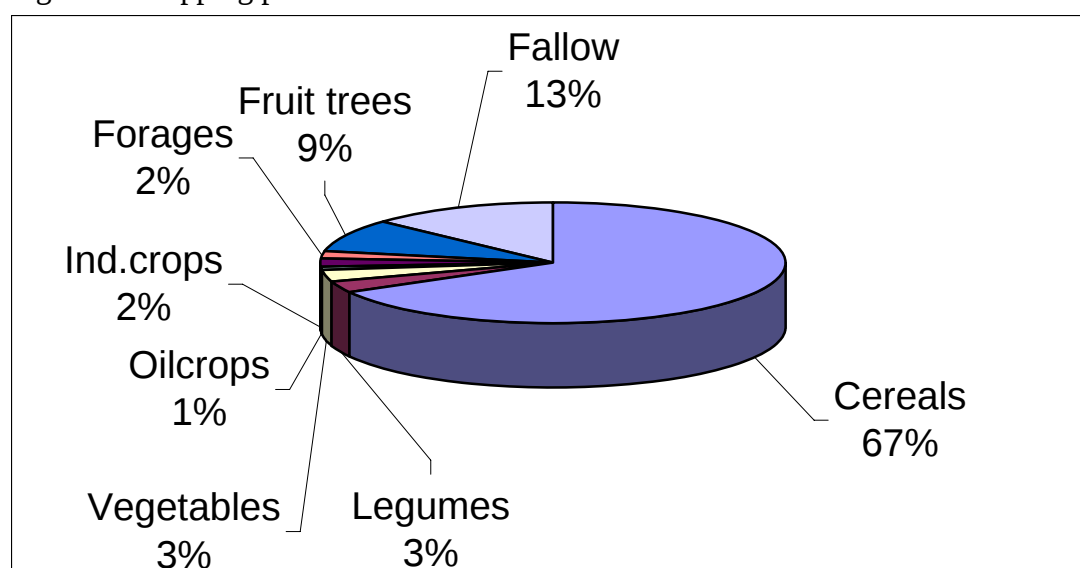


Figure 2. Cropping pattern in Morocco



Source: Agricultural Census, 1996

Figure 3. Agricultural & Cereal Production indices

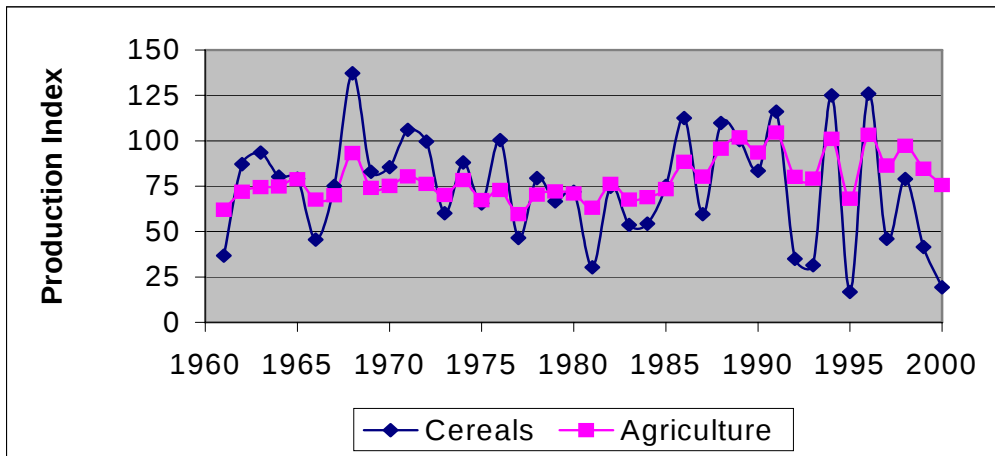


Figure 4. Evolution of soft wheat harvested acres.

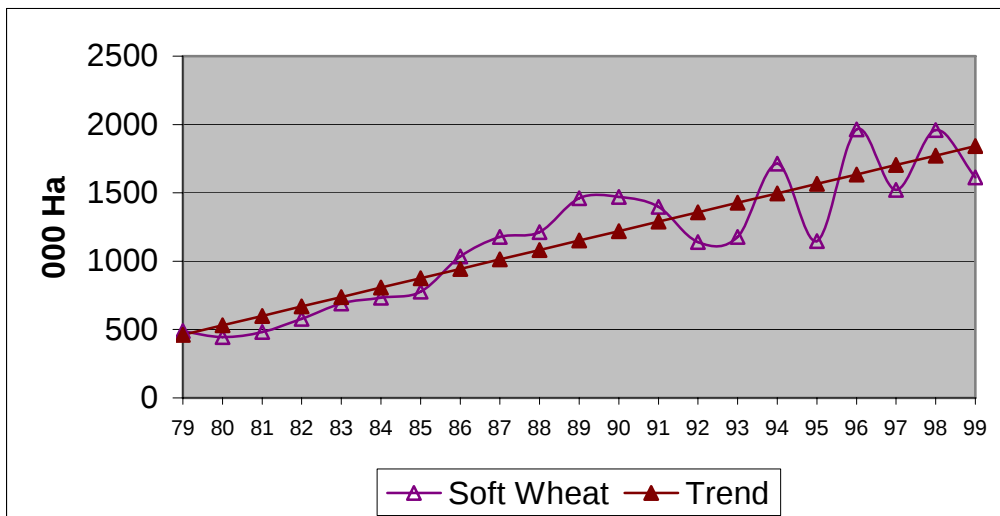


Figure 5. Evolution of Barley acreage

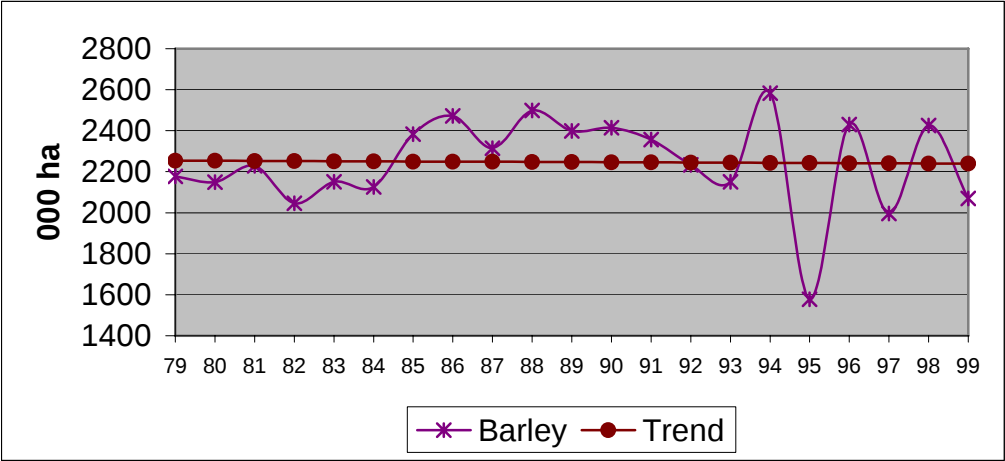


Figure 6. Evolution of Barley Imports

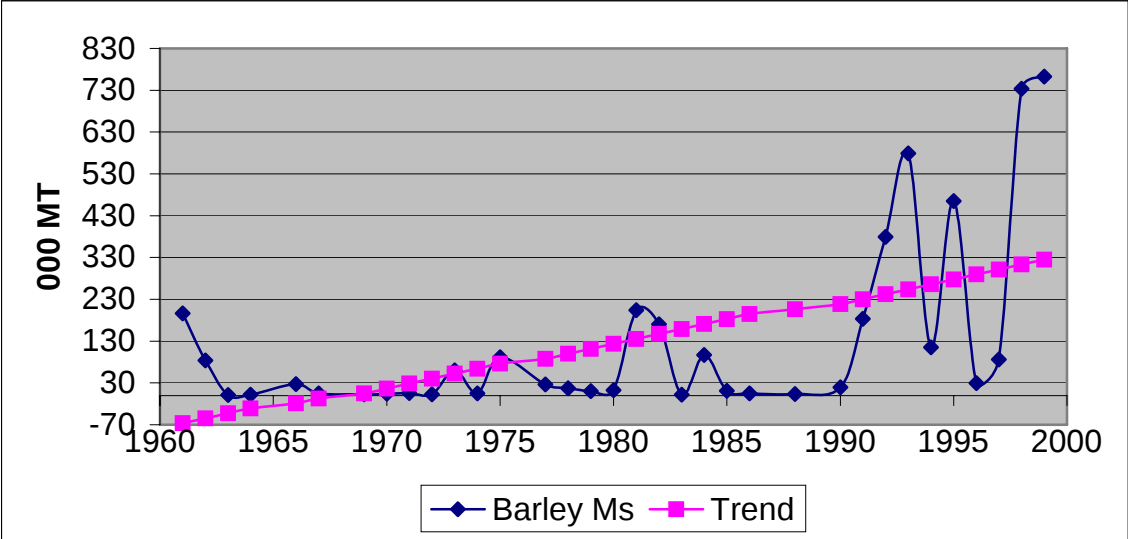


Table 1. Coefficients of variation for cereal production

Product	1971-1983		1987-1999	
	Yield	Production	Yield	Production
Total Cereals	0.25	0.25	0.41	0.47
Hard Wheat	0.20	0.21	0.41	0.48
Soft Wheat	0.26	0.31	0.38	0.49
Barley	0.33	0.31	0.45	0.52

Table 2. Production shares for cereal activities in rainfed zones (in percentage)

	Hard Wheat	Soft Wheat	Barley	Maize
Rainfed Favorable	50	58	25	5
Rainfed Intermediate	26	17	16	52
Rainfed dry	24	25	59	43
Total	100	100	100	100

Table 3. Base year Risk premia (in percentage)

Activity	Irrigated	Rainfed favorable	Rainfed Intermediate	Rainfed dry
Soft wheat	4.3	16.1	24.8	20
Hard Wheat	3.6	16.6	34.5	22.3
Barley	9	10.9	21.5	10.4
Maize	15.9	11.5	21.1	33.1

Source: Calculated from historic annual real returns data (1990-1999)

Table 4. Applied Climate productivity shocks in different states of nature.

	Hard Wheat	Soft Wheat	Barley	Maize
Irrigated				
Good	1.27	1.35	1.53	1.43
Bad	0.79	0.85	0.79	0.38
Rainfed Favorable				
Good	1.53	1.50	1.63	1.26
Bad	0.43	0.43	0.56	0.57
Rainfed Intermediate				
Good	1.78	1.69	1.66	1.41
Bad	0.22	0.28	0.26	0.43
Rainfed Dry				
Good	1.73	1.77	1.70	1.51
Bad	0.65	0.70	0.63	0.38

Table 5. Aggregate marketed output changes (in percentage from base)

Commodity	S1	S2
Hard wheat	52	-46
Soft wheat	50	-38
Barley	66	-42
Maize	44	-60

Table 6. Price change in different states of nature (in percentage from base)

Commodity	S1	S2
Hard Wheat	-29	20
Soft Wheat	-21	14
Barley	-35	40
Maize	-9	22
Other Agriculture	-4	5
Livestock	10	-10

Table 7. Changes in Equivalent variation (in percentage from base)

	Base ^a	S1	S2
Landless	15.7	23.7	-15.4
S.farmers	16	16.3	-14.9
M.farmers	16.1	4.4	-6.6
L.farmers	12.9	2.6	-4.2
Urban poor	6.9	23.1	-12.9
Urban Non Poor	139.2	10	-4.7

^a: Denominated in billions of Dirhams

Table 8. Factor income changes under different states of nature (as percentage from a changing base)

	Normal Year base*	Tariff Lib ⁺	Good Year base*	Tariff Lib ⁺	Bad year Base*	Tariff Lib ⁺
Rainfed favorable land	2.87	-28.0	2.93	-25.2	2.34	-14.5
Rainfed Intermediate Land	0.87	-47.8	0.98	-45.9	0.42	-18.8
Rainfed Dry Land	2.74	-24.6	3.20	-22.6	2.39	-14.9
Capital Crops	6.25	-35.0	6.28	-30.7	5.77	-30.6
Other rural Capital	0.09	-7.1	0.09	-8.2	0.08	-6.5
Livestock Capital	12.59	2.5	15.73	-7.9	9.57	9.3
Irrigated land	7.79	-28.4	7.39	-22.3	8.10	-31.8
Rural labor	17.52	2.2	21.94	-9.2	14.46	8.1
Urban Labor	92.90	4.0	117.02	-10.3	78.85	9.7
Urban Capital	133.38	4.2	128.47	5.3	138.66	2.6

*: Denominated in billions of dirhams

⁺: Denominated in percentage terms

Table 9. Change in Equivalent variation for different households (in percentage)

Households	Base ^a	S0		S1		S2	
		Exp 1	Tariff lib	Exp 1	Tariff lib	Exp 1	Tariff lib
Landless	15.7	--	4.3	23.7	16.9	-15.4	-6.2
S.farmers	16	--	-4.8	16.3	5.6	-14.9	-15.1
M.farmers	16.1	--	-10.6	4.4	-6	-6.6	-14.6
L.farmers	12.9	--	-10.7	2.6	-7.6	-4.2	-12.8
Urban poor	6.9	--	5.5	23.1	15.7	-12.9	-2.7
Urban Non Poor	139.2	--	3.2	10	7.2	-4.7	0.3

^a: Denominated in billions of Dirhams